

San Juan River Water Quality Summary Report

Hogback Diversion Site

2nd Quarter Calendar Year 2015

Includes Data Collected June 2014 – June 2015

General

Water quality investigations are underway by the United States Geological Survey (USGS) and the Bureau of Reclamation (Reclamation) documenting seasonal variations in the San Juan River near the Hogback Diversion. The typical high solids events in the San Juan River occur as a result of snowmelt in March-May and monsoonal storms in July-September. The expectation is for numerous spikes in the solids levels to occur during these time periods.

The desired design data to be obtained from these investigative results are frequency of high solids loading events, speed with which the loadings increase and subside, length of time that high loadings persist, and seasonal trend differences.

Sampling Locations and Frequency

USGS, under an Interagency Agreement with Reclamation, installed a sampling station immediately downstream of the Hogback Diversion headworks in June 2014. Flow and water quality measurements are collected at this location year-round. This location is shown in Figure 1. Also at this location, a nephelometer measures turbidity every 15 minutes, and an automated ISCO sampler takes a physical suspended sediment concentration (SSC) sample daily each afternoon, and every two hours when turbidity values exceed 200 NTU. Monthly samples are also collected by USGS for solids, minerals, and metals analysis. Depth integrated samples collected monthly are analyzed for both SSC as well as gradation.

During irrigation season, Reclamation collects grab samples at least weekly for total suspended solids (TSS), turbidity, total organic carbon (TOC), and dissolved organic carbon (DOC) at the following locations: 1) over the weir at its upper end; 2) over the weir at its lower end; and 3) before the weir in the Hogback Diversion channel at the weir's upper end (bypass gate). These discreet samples are transported to a local laboratory for analysis. Reclamation also installed a Hach meter to collect either continuous TSS or turbidity measurements every 30 minutes over the weir at its upper end. Reclamation's sampling locations during irrigation season are shown in Figure 2.

During non-irrigation season, Reclamation collects grab samples at least weekly for TSS, turbidity, TOC, and DOC at the upstream side of the Hogback Diversion headworks adjacent to the trash racks. These discrete samples are transported to a local laboratory for analysis. Also, Reclamation's continuous (30 minute interval) TSS or turbidity meter is moved to the upstream side of the Hogback Diversion headworks. Reclamation's sampling locations during non-irrigation season are shown in Figure 3.

Changes in Procedures or Conditions

Diversion operations were in irrigation season for this quarter. Reclamation's Hach meter was reconfigured to measure turbidity and began collecting this data in late May 2015.

Data Summary

This report presents cumulative data from the 3rd quarter of 2014 through 2nd quarter of 2015 (July 2014 – June 2015). When available, the data also includes measurements and samples from June 2014. All USGS turbidity data in this report are provisional and subject to revision until they have been reviewed and receive final approval from internal USGS staff. Review and final approval typically occurs at the beginning of each new fiscal year for the past fiscal year (October to September). All other USGS data presented in this report has been reviewed and approved. The USGS data can be accessed at: http://waterdata.usgs.gov/nm/nwis/uv?site_no=09367580. Reclamation data is not accessible online but is available upon request.

The continuous turbidity measurements collected by USGS are shown in Figure 4. Their instrumentation does not have the dynamic range to record values greater than 3,000 FTU and actual turbidity may have been higher the last half of 2014. Reclamation has discussed this limitation with USGS and agreed that the USGS instrumentation will be used for readings below 3,000 FTU. The turbidity values from January 2015 through March 2015 are low because the water level in the Diversion channel was too low to measure. It is anticipated that many of the data points at or near zero will be removed once the data is reviewed and approved by USGS.

SSC data collected by the USGS upstream of the Diversion channel is shown in Figure 5. Gaps in this data are due to low water levels in the Diversion channel when water samples could not be taken. This data has been reviewed and approved by USGS.

Table 1 shows the results of the monthly water quality sampling performed by the USGS. For reference, regulatory drinking water maximum contaminant levels (MCL) are also shown. Raw water sample results exceeding MCLs are shown in bold. Unless noted otherwise, MCLs are primary standards. Four USGS sampling events occurred during the current reporting period. In November 2015, January 2015, and February 2015, water levels in the Diversion channel were too low to sample.

Four USGS sediment particle size analyses were performed during the current reporting period. All reported sediment particle size data are presented in Table 2 and in graphical form in Figure 6. The gradation is done by the USGS lab by pipette withdrawal, if there is 1 gram or more of sediment finer than 62 micron in the sample. If there is not sufficient fine material for size analysis in the fines range, the total fines are weighed and included as percent finer than 62 microns. The sand particles are separated by wet sieve. The resulting sample is weighed and reported in standard sieve sizes.

Continuous (30 minute interval) TSS measurements collected by Reclamation are shown in Figure 7. This data is only available through mid-January 2015, after which the meter was without power. Note the maximum TSS measurements shown in Figure 7 are 34,845 mg/L. The installed instrumentation does not have the dynamic range to record TSS values greater than 34,845 mg/L and actual TSS may have been higher. The continuous TSS measurements taken from 11/10/14 through 1/8/15 had little variation and were approximately two orders of magnitude higher than the corresponding data analyzed by a lab. This period of consistently high TSS measurements was after the meter was moved to the upstream side of the

Hogback Diversion headworks. This portion of data was deemed to be erroneous and removed from the data set.

Continuous (30 minute interval) turbidity measurements collected by Reclamation are shown in Figure 8. In late May 2015 Reclamation's Hach meter was reconfigured to measure turbidity.

Samples are collected by Reclamation at least weekly and analyzed in a laboratory for TSS, turbidity, TOC, and DOC. The results of the TSS lab analysis are shown in Figure 9. The results of the turbidity lab analysis are shown in Figure 10. The TOC and DOC results are shown in Figure 11. Given the margin of analytical error associated with these carbon tests, the results appear acceptable despite the prevalence of DOC values exceeding TOC values.

Weekly samples analyzed in the laboratory can serve as a check on the instrument that is recording continuous data; however, they are of limited value for estimating the solids loading over time as they are not frequent enough. Figure 12 compares the weekly Reclamation TSS samples (shown in Figure 9) with the closest continuous TSS reading recorded by the Reclamation TSS probe (shown in Figure 7). As noted above, actual TSS values may have been higher than the maximum TSS measurements of 34,845 mg/L measured by the TSS probe. At most, the weekly sample and continuous sample were taken 30 minutes apart. As described above, the TSS probe location and weekly grab sample locations differ between irrigation and non-irrigation season.

Figure 13 compares the weekly Reclamation turbidity samples (shown in Figure 10) with the continuous turbidity reading recorded by the USGS nephelometer (shown in Figure 4) and the continuous turbidity reading recorded by the Reclamation Hach meter (shown in Figure 8) at approximately the same time. At most, the weekly sample and continuous sample were taken 15 minutes apart. During irrigation season the Reclamation weekly turbidity sample used for comparison is the one taken adjacent to the upstream end of the fish weir (bypass gate) in the Hogback Diversion. During non-irrigation season the weekly Reclamation sample used for comparison is the one taken on the upstream side of the Hogback Diversion headworks. As described above, the USGS turbidity data has not yet been reviewed and approved.

Figure 14 compares the SSC data collected by the USGS (shown in Figure 5) with the continuous TSS reading recorded by the Reclamation Hach meter (shown in Figure 7). As noted above, actual TSS values may have been higher than the maximum TSS measurements of 34,845 mg/L measured by the Hach meter. There is not an empirical relationship between SSC and turbidity or TSS. Every water body has to have a site specific evaluation performed in order to make direct mathematical correlations between these two parameters.

Figure 15 compares the continuous turbidity readings recorded by USGS (shown in Figure 4) with the continuous turbidity reading recorded by the Reclamation Hach meter (shown in Figure 8). As described above, the USGS turbidity data has not yet been reviewed and approved.

Figure 16 plots the USGS SSC measurements (shown in Figure 5) versus USGS turbidity measurements (shown in Figure 4). Note the y-axis of the plot is log scale. Although the USGS turbidity instrument range is limited to < 3000-FTU, no turbidity measurements in this data set reached this upper limit. As

seen in the figure, a linear correlation does not exist for this data set. A potential correlation will be investigated after the turbidity data set is validated by USGS as previously described.

Figure 17 plots the weekly Reclamation TSS measurements (shown in Figure 9) versus the weekly Reclamation turbidity measurements (shown in Figure 10). A strong linear correlation appears to exist for this data set, as seen by the linear trend line shown on the figure with a R-squared value of 0.989.

Figure 18 plots the same data, but only for turbidity values less than 1,000 NTU. This data set includes approximately 94% of the data points that are included in Figure 17. A strong linear correlation also appears to exist for this data set, as seen by the linear trend line shown on the figure with a R-squared value of .929.

Recommendations

- Obtain current Public Service Company of New Mexico (PNM) turbidity data. (Ongoing)
- Develop protocols and criteria for validating/filtering Reclamation data to ensure anomalies and/or erroneous data is noted.

Figure 1. USGS Sampling Location



Figure 2. Reclamation Sampling Locations – Irrigation Season

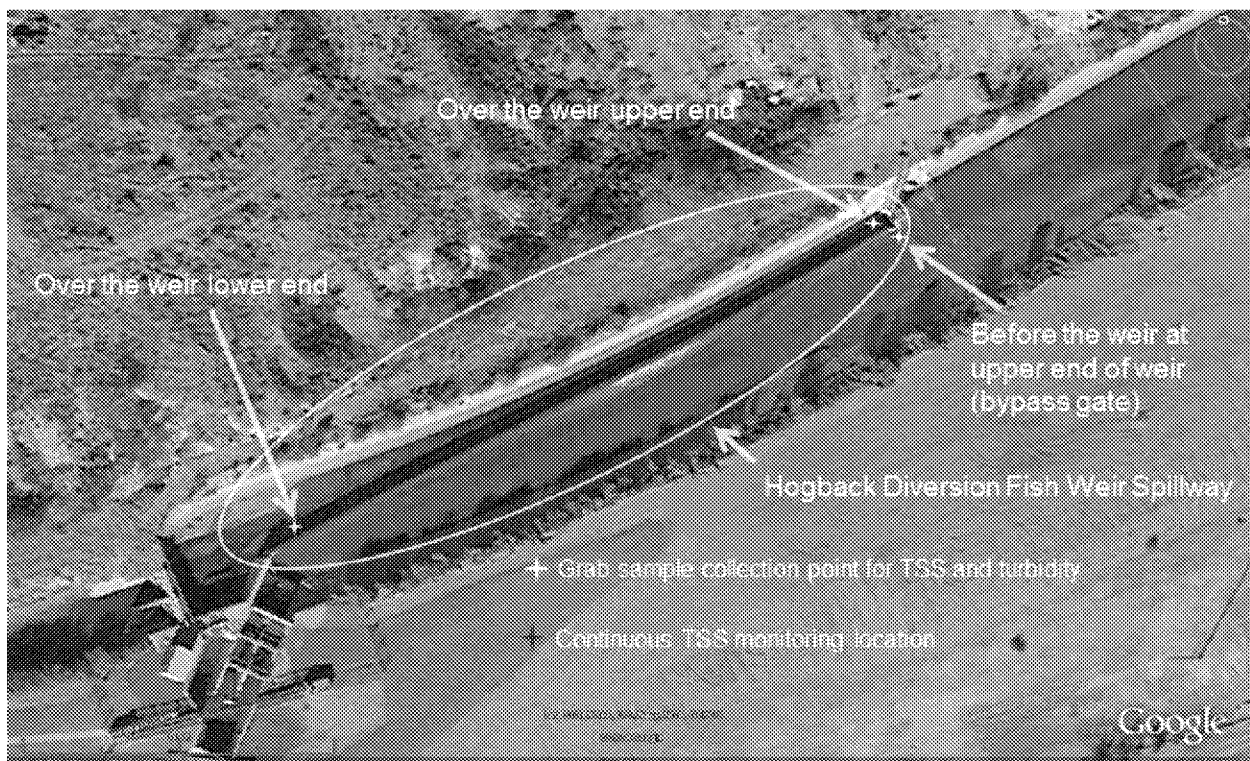


Figure 3. Reclamation Sampling Locations – Non-Irrigation Season

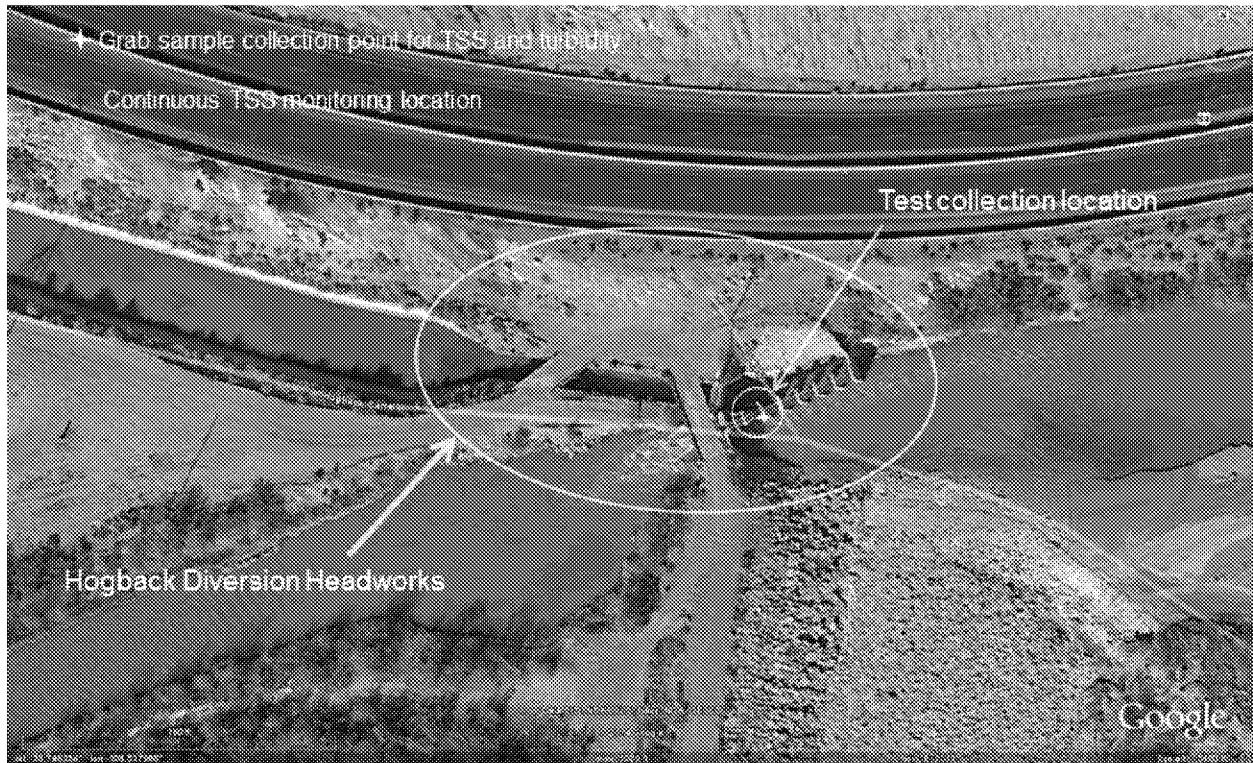
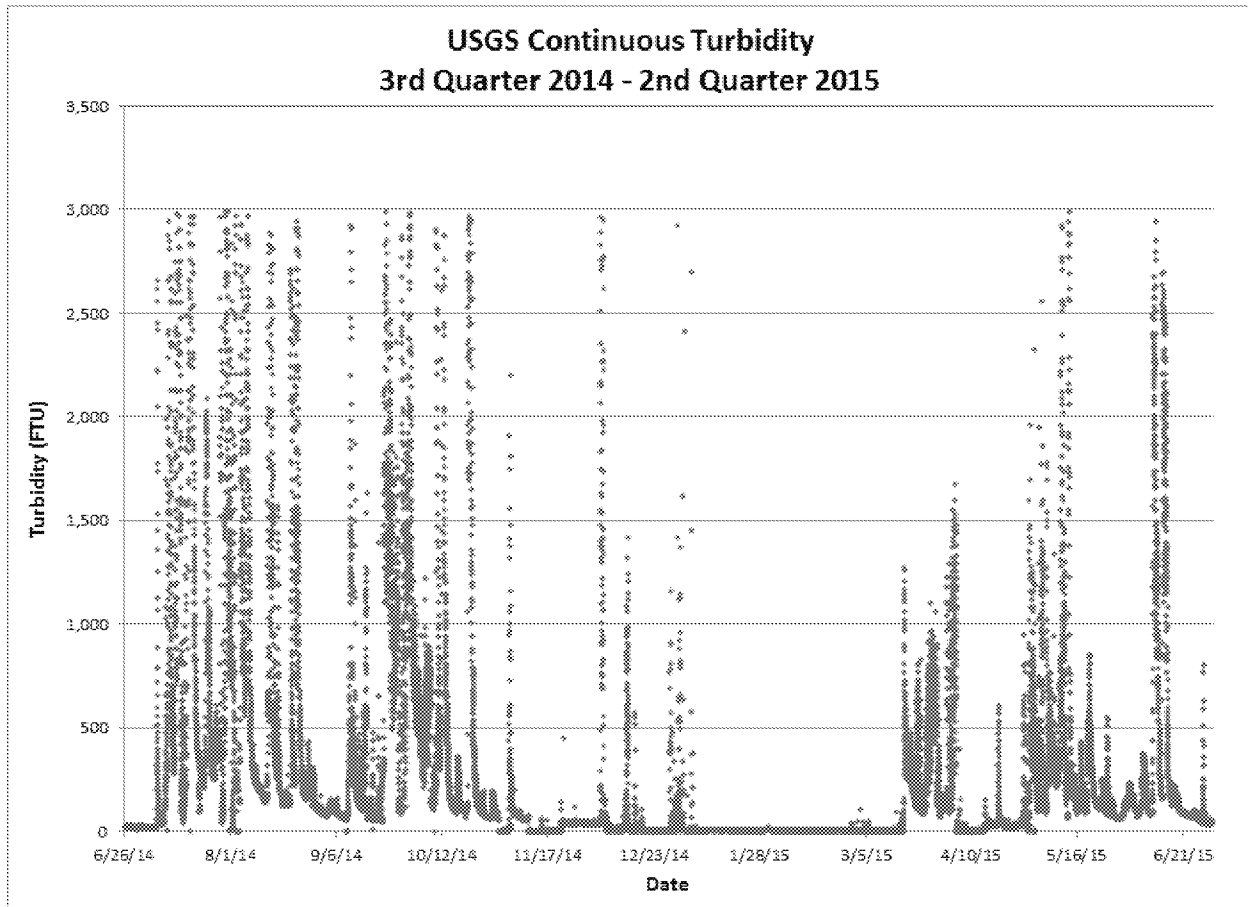


Figure 4. USGS Turbidity Data



Note: Instrument range is limited to < 3000 FTU. This data is provisional and subject to revision.

Figure 5. USGS Suspended Sediment Concentration Data

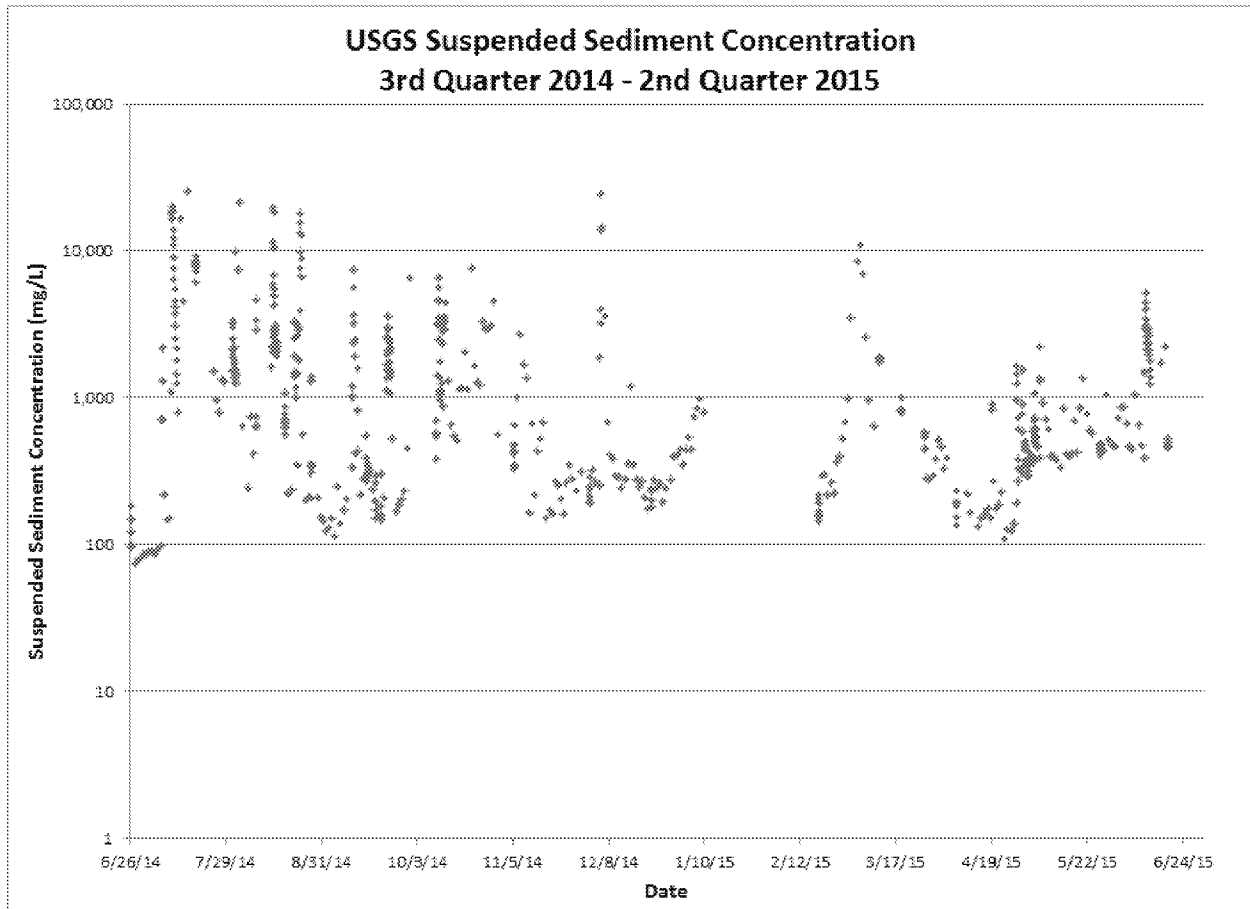


Table 1. USGS Water Quality Data

Parameter	Units	MCL	6/26/14 13:40	7/30/14 9:00	8/19/14 8:15	9/23/14 10:30	10/29/14 11:10	3/3/15 9:30	4/13/15 14:05	4/28/15 8:45	5/27/15 9:30	6/30/15 8:10
Water temperature	°C		20.8	20.2	20.4	18	9.2	6.2	15.4	13.5	13.8	17
Color	Pt-Co units	15 ¹	12	20	15	30	15	20	15	15	15	15
Conductance	µS/cm		388	588	476	498	573		604		419	287
Dissolved oxygen	mg/L		8.5	6.8	7.4	7.6	10.3	10.2	9.8	8.6	8.4	
pH (field)	units	6.5-8.5 ¹	8.3	8	8.2	8.1	8.1	8.2	8.2	8.1	8.2	8.1
Carbonate	mg/L		0.7	0.8	1	0.5	1.2	1.3	1.2	1	1	0.3
Bicarbonate	mg/L		102	135	133	142	150	168	138	133	128	74.4
Alkalinity	mg/L as CaCO3		84.9	112	111	117	125	140	115		107	61.7
Total solids	mg/L		299	13600	862	4960	663	6010	477	473	601	
Total dissolved solids	mg/L	500 ¹	239	396	304	550	381	497	397	390	256	186
Ammonia, dissolved	mg/L as N		< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.03	0.02	< 0.01	0.01	0.02
Nitrite, dissolved	mg/L as N	1	0.002	0.005	0.008	0.01	0.002	0.009	0.005	0.004	0.005	0.005
Nitrate, dissolved	mg/L as N	10	0.147	0.504	0.397	0.367	0.501	0.818	0.505	0.475	0.287	0.205
Phosphorus, dissolved	mg/L as P		0.013	0.035	0.037	0.182	0.009	0.017	0.046	0.025	0.016	0.018
Phosphorus, total	mg/L as P		0.101	7.36	0.346	2.58	0.219	1.83	0.102	0.209	0.332	0.137
Orthophosphate, dissolved	mg/L as P		0.011	0.026	0.038	< 0.016	0.008	0.016	0.041	0.021	0.016	0.016
Organic carbon, dissolved	mg/L		1.55	3.88	2.67	2.53	3.02	2.83	2.84	2.79	2.72	1.63
Carbon (inorganic + organic)	mg/L		3	98.8	3.73	34.9	2.53	33.4	1.41	3.83	4.06	2.15
Hardness	mg/L as CaCO3		150	160	179	209	222	208	239	236	172	119
Hardness, non-carbonate	mg/L as CaCO3		65	47	68	91	96	67	124	125	65	57
Calcium, dissolved	mg/L		48.5	53.4	56.6	65.5	69.7	68.3	76.5	74.6	55.5	38.5
Magnesium, dissolved	mg/L		6.87	6.22	8.96	10.7	11.3	8.7	11.4	11.9	7.9	5.33
Sodium, dissolved	mg/L		18.8	53	28.7	29	36.2	86.1	43.8	46.6	19.8	11.5
Potassium, dissolved	mg/L		1.64	3.16	2.56	3.82	2.56	2.96	2.24	2.66	1.46	1.2
Bromide, dissolved	mg/L										< 0.030	< 0.030
Chloride, dissolved	mg/L	250 ¹	9.02	10.6	10.9	14.3	15.4	18.6	16.1	15.1	8.5	5.08
Sulfate, dissolved	mg/L	250 ¹	95.9	145	112	120	155	228	167		84.5	63.4
Fluoride, dissolved	mg/L	2 ¹ , 4	0.31	0.47	0.3	0.35	0.35	0.36	0.3	0.28	0.23	0.24
Silica, dissolved	mg/L as SiO2		6.66	9.02	8.53	15.4	8	8.02	6.77	7.73	7.36	6.36
Arsenic, dissolved	µg/L		0.49	0.98	1	1.1	0.57	0.89	0.67	0.71	0.64	0.49
Arsenic, total	µg/L								1	2.1	3.7	1.6
Barium, dissolved	µg/L		53.8	87.2	69.7	157	84.5	75.2	77.9	64.7	74.5	53.5
Barium, total	µg/L	2000	128	3290	265	1170	181	1110	95.7	151	274	110
Beryllium, dissolved	µg/L		< 0.020	< 0.020	< 0.020	0.246	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Beryllium, total	µg/L	4	0.19	9.55	0.47	2.39	0.41	5.56	0.09	0.17	0.47	0.13
Boron, dissolved	µg/L		32	52	46	53	49	59	46	44	31	19
Cadmium, dissolved	µg/L		< 0.030	< 0.030	< 0.030	0.142	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	0.065

Parameter	Units	MCL	6/26/14 13:40	7/30/14 9:00	8/19/14 8:15	9/23/14 10:30	10/29/14 11:10	3/3/15 9:30	4/13/15 14:05	4/28/15 8:45	5/27/15 9:30	6/30/15 8:10
Cadmium, total	µg/L	5	0.176	1.99	0.119	1.23	0.088	0.442	0.064	0.076	0.431	0.342
Chromium, dissolved	µg/L		< 0.30	< 0.30	< 0.30	1.2	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
Chromium, total	µg/L	100	1.5	60.7	3.9	18.6	2.9	20.4	0.61	1.5	3.2	1.1
Cobalt, dissolved	µg/L		0.106	0.454	0.339	1.83	0.143	0.424	0.37	0.739	0.173	0.123
Cobalt, total	µg/L		2.5	80.3	4.4	23.7	2.7	33.6	0.6	1.8	5.4	1.6
Copper, dissolved	µg/L		0.85	1.9	0.95	4.6	0.88	1.2	1.1	0.81	1.1	1.3
Copper, total	µg/L	TT ² , 1000 ¹ , 1300 ³	6.3	183	8.9	49.4	8.9	81	6.3	4.3	14.5	9
Iron, dissolved	µg/L		7.1	49.5	15.5	2630	11.3	21.4	7.1	5.7	15.2	38.6
Iron, total	µg/L	300 ¹								2860	7780	2640
Lead, dissolved	µg/L		< 0.040	0.096	0.057	5.36	< 0.040	0.08	< 0.040	< 0.040	0.102	0.461
Lead, total	µg/L	TT ² , 15 ³	11.9	149	8.54	69.7	6.4	71.2	1.88	4.16	21.2	17.1
Manganese, dissolved	µg/L		0.78	1.64	4.63	151	7.15	4.1	11.4	15.6	4.02	7.91
Manganese, total	µg/L	50 ¹	414	5750	369	1920	193	1590	64.3	215	768	196
Thallium, dissolved	µg/L		< 0.030	< 0.030	< 0.030	0.044	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Thallium, total	µg/L	2	< 0.06	0.86	0.13	0.49	0.08	0.55	< 0.06	< 0.06	0.12	< 0.06
Molybdenum, dissolved	µg/L		1.32	2.67	1.58	0.774	1.56	1.99		1.47	1.03	0.91
Molybdenum, total	µg/L		1.12	0.7	1.26	0.97	1.3	0.45		1.44	0.91	0.88
Nickel, dissolved	µg/L		0.99	1.3	1.1	3.4	1.2	1.4		0.88	0.8	0.48
Nickel, total	µg/L		2.8	99.7	5.8	32.1	3.2	35		2.4	5.8	1.8
Silver, dissolved	µg/L		< 0.020	< 0.020	< 0.020	0.04	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	0.129
Silver, total	µg/L	100 ¹	0.05	1.57	0.042	0.374	0.037	0.423	< 0.030	< 0.030	0.167	0.1
Strontium, dissolved	µg/L		548	650	679	792	902	1060	875	830	608	377
Strontium, total	µg/L		613	2080	736	1050	912	1760	890	958	588	430
Vanadium, dissolved	µg/L		0.54	2.1	1.6	5	0.69	1.3	0.79	0.81	0.76	0.56
Zinc, dissolved	µg/L		< 2.0	< 2.0	< 2.0	22	< 2.0	< 2.0	< 2.0	< 2.0	2.1	5.5
Zinc, total	µg/L	5000 ¹	59	404	36.2	244	27	145	12.8	21.4	148	80.4
Antimony, dissolved	µg/L		0.175	0.307	0.197	0.107	0.125	0.208	0.163	0.258	0.14	0.136
Antimony, total	µg/L	6	0.18	< 0.18	< 0.18	0.22	< 0.18	< 0.18	< 0.18	< 0.18	0.2	0.2
Aluminum, dissolved	µg/L		34.1	28.8	10.7	2380	14.9	19	22.6	8.6	28.5	127
Aluminum, total	µg/L	50-200 ¹	2170	105000	5680	26500	5280		935	2010	5130	1350
Lithium, dissolved	µg/L		19.8	25.5	27.2	34.5	26.3	28.5	22.8	23.3	15.9	10.8
Lithium, total	µg/L		20.7	88.3	29.9	55.7	32.1	60.8	22.8	24.4	18.4	10.2
Selenium, dissolved	µg/L		0.36	1.1	0.47	0.51	0.55	1.5		0.52	0.44	0.25
Selenium, total	µg/L	50	0.334	1.18	0.432	0.982	0.511	1.47		0.571	0.385	0.269
Mercury, total	µg/L	2	< 0.005	0.273	0.009	0.082	0.007	0.127	< 0.005	< 0.005		
Gross beta	pCi/L	4 MREM/yr	3.6	4.8	4.5	7.4	4.4	6.7	3.2	3.6	2.3	
Gross alpha	pCi/L	15	2	R ⁴ 1.8	R ⁴ 0.5	5.4	3	5.2	1.5	1.5	R ⁴ 0.4	
Ra-226	pCi/L	5 (226 + 228)	0.07	0.13	0.106	0.16	0.094	0.14	0.09	0.22	0.46	R ⁴ 0.08
Ra-228	pCi/L	5 (226 + 228)	0.27	0.33	0.51	R ⁴ 0.5	0.44	R ⁴ 0.17	R ⁴ 0.02	0.5	0.39	R ⁴ 0.00

Parameter	Units	MCL	6/26/14 13:40	7/30/14 9:00	8/19/14 8:15	9/23/14 10:30	10/29/14 11:10	3/3/15 9:30	4/13/15 14:05	4/28/15 8:45	5/27/15 9:30	6/30/15 8:10
Uranium, dissolved	µg/L		1.18	1.96	1.35	1.58	1.77	2.64	2.17	1.94	1.4	0.723
Uranium, total	µg/L	30	1.3	6.3	1.51	3.08	1.9	4.05	2.05	1.99	1.73	0.964
Giardia	cysts/10 L	TT ²		< 5	4	8	< 0.095	< 8		0	2	0
Cryptosporidium	cysts/10 L	TT ²		< 5	< 2	3	< 0.095	< 8		< 0.433	< 0.421	< 0.391

1. Secondary standard
2. Treatment technique (TT) - A required process intended to reduce the level of a contaminant in drinking water.
3. Action Level
4. Radchem non-detect, below sample-specific critical level

Table 2. USGS Sediment Particle Size Data

Parameter	Units	8/18/2014 14:04	8/27/2014 12:31	10/9/2014 13:00	11/5/2014 12:55	12/1/2014 15:01	12/22/2014 14:55	2/18/2015 12:47	3/11/2015 11:46	3/26/2015 18:00	4/6/2015 15:55	5/1/2015 10:30	5/26/2015 13:50	6/18/2015 12:10
Suspended Sediment Concentration	mg/L	717	1380	569	435	194	231	217	1890	446	135	344	487	527
Sieve diameter - smaller than 1 mm	%	100	100	100	100	100	100	100	100	100	100	100	100	100
Sieve diameter - smaller than 0.5 mm	%	100	100	100	96	100	100	100	100	100	100	100	100	100
Sieve diameter - smaller than 0.25 mm	%	99	99	99	86	95	95	89	100	99	100	98	99	99
Sieve diameter - smaller than 0.125 mm	%	96	95	80	62	59	62	69	97	89	90	88	90	92
Sieve diameter - smaller than 0.0625 mm	%	72	67	62	43	36	39	54	93	75	73	69	76	76
Fall diameter (DI water) - smaller than 0.031 mm	%	50	52	46					87	57			62	61
Fall diameter (DI water) - smaller than 0.016 mm	%	37	46	36					84	40			49	52
Fall diameter (DI water) - smaller than 0.008 mm	%	33	43	32					76	32			42	44
Fall diameter (DI water) - smaller than 0.004 mm	%	31	41	29					64	26			40	40
Fall diameter (DI water) - smaller than 0.002 mm	%	27	37	24					54	23			30	36

Figure 6. USGS Sediment Particle Size Distribution

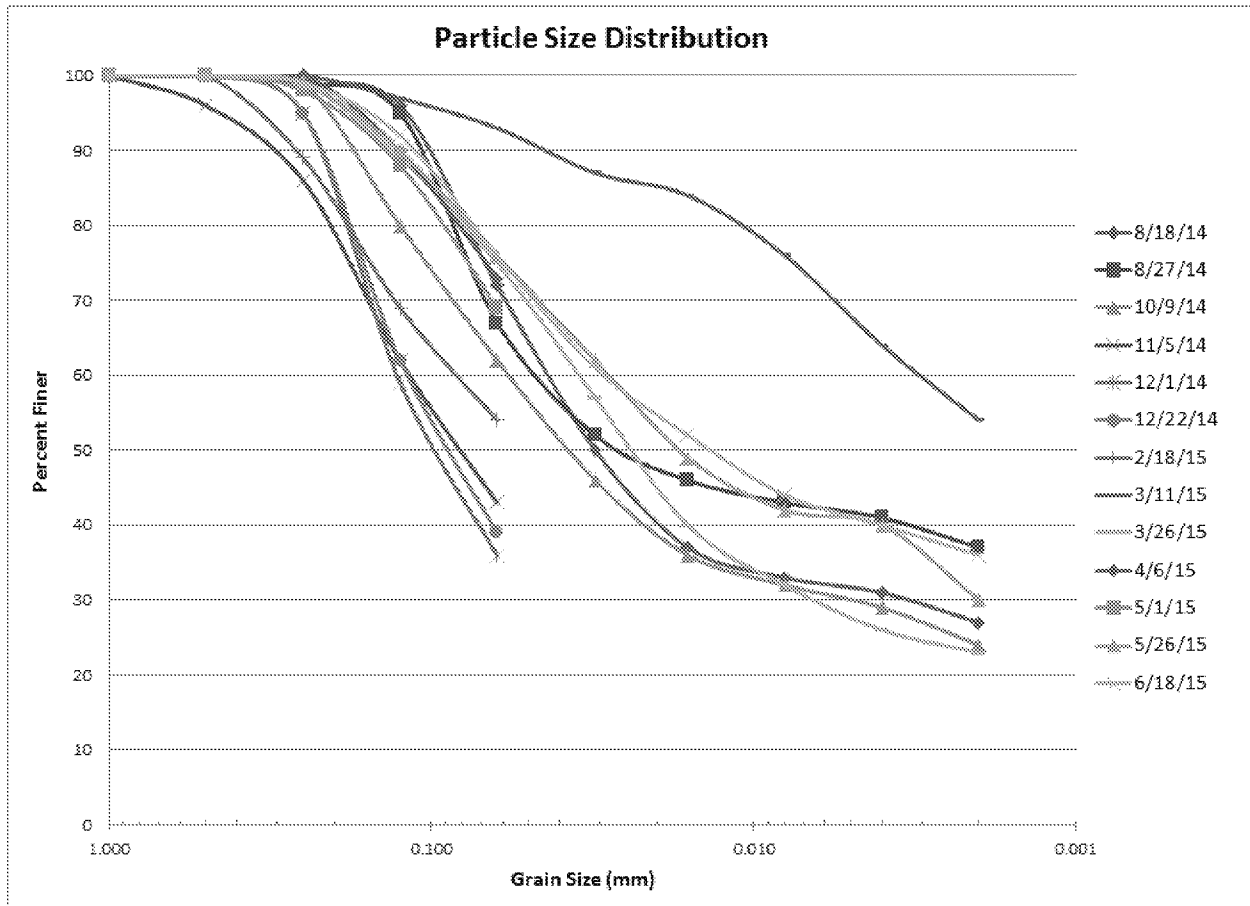
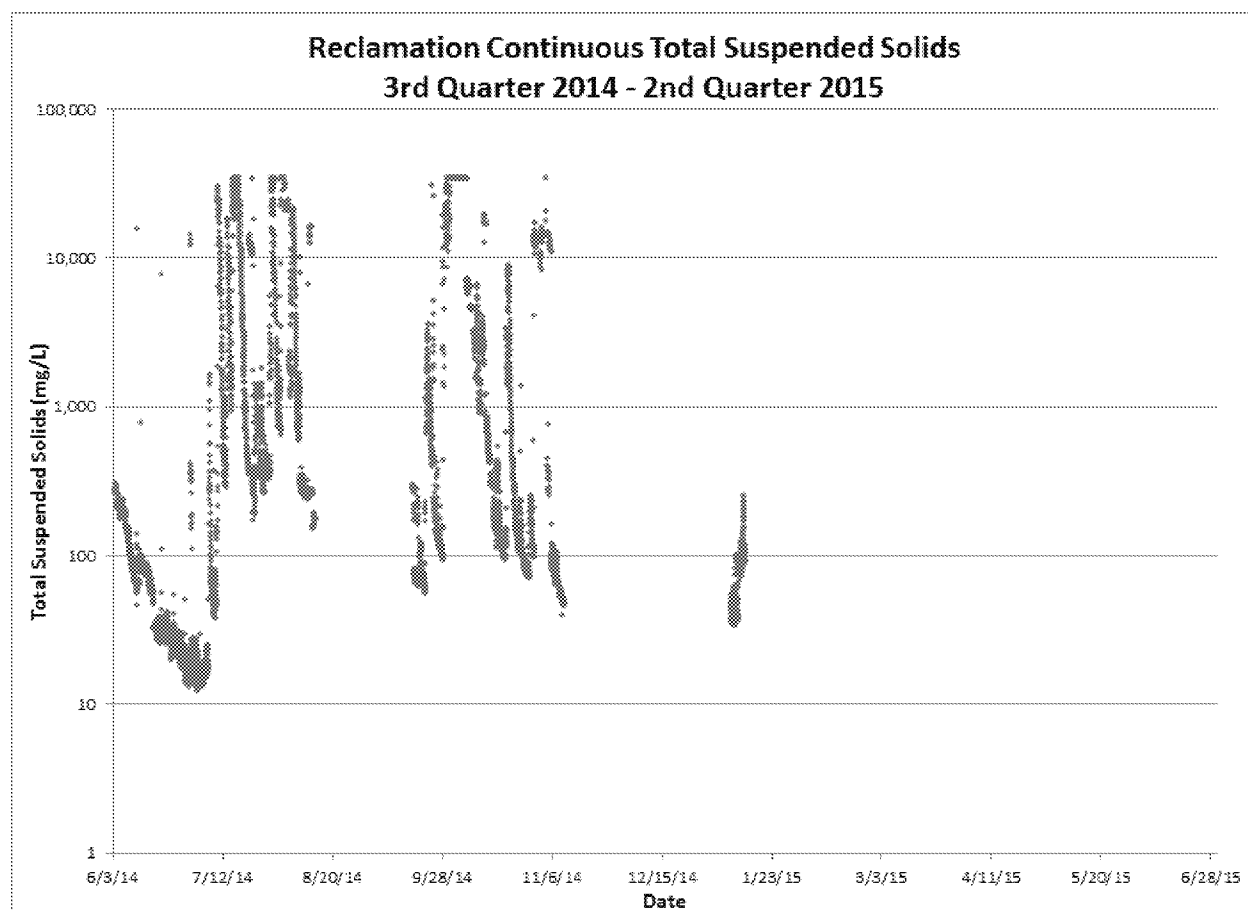


Figure 7. Reclamation Continuous Total Suspended Solids Data



Note: Continuous instrument range is limited to $\leq 34,845$ mg/L. Continuous data collected from 11/10/14 to 1/8/15 differed significantly from lab results, was deemed erroneous, and was removed from the graph. No continuous Reclamation TSS data was collected after January 13, 2015 because power was not available at the site.

Figure 8. Reclamation Continuous Turbidity Data

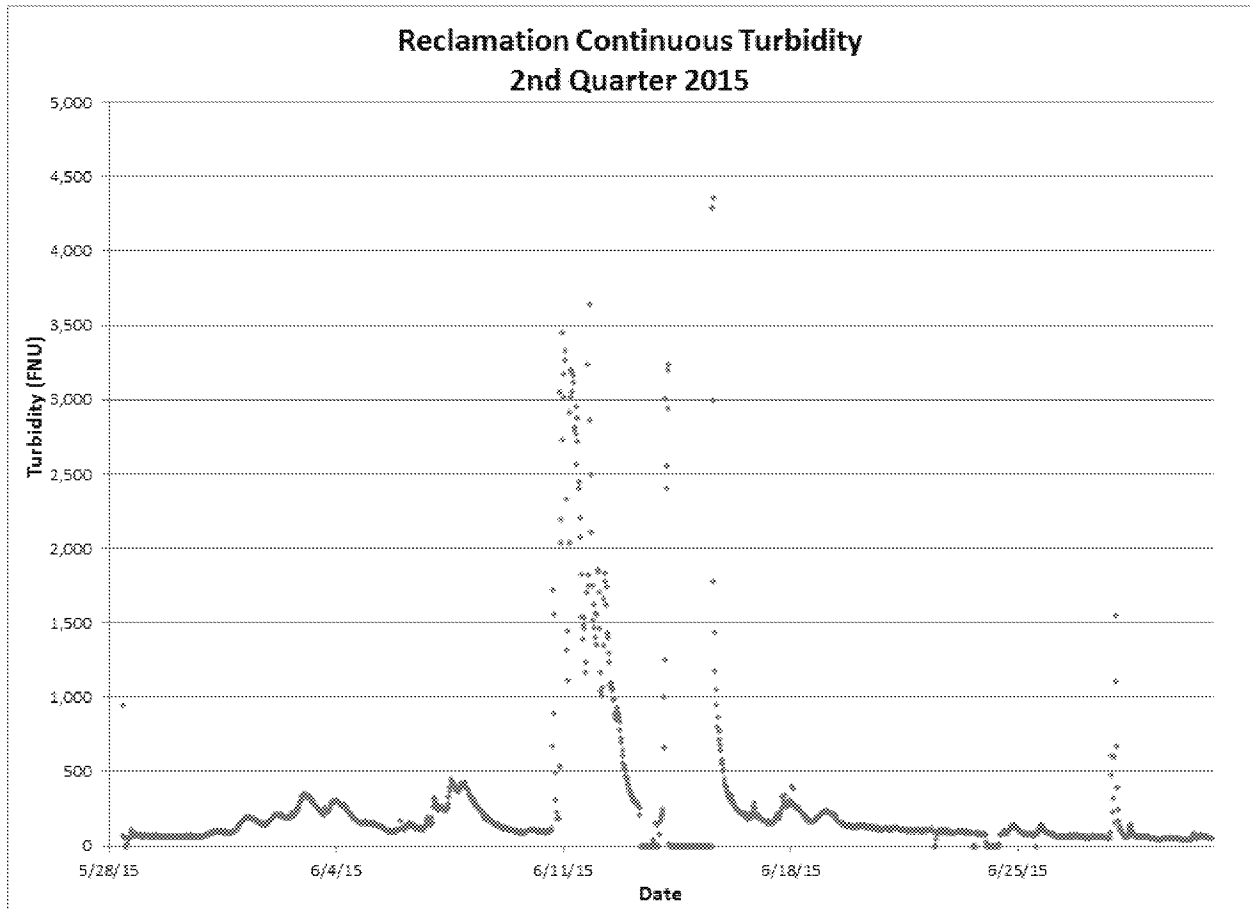


Figure 9. Reclamation Weekly TSS Data

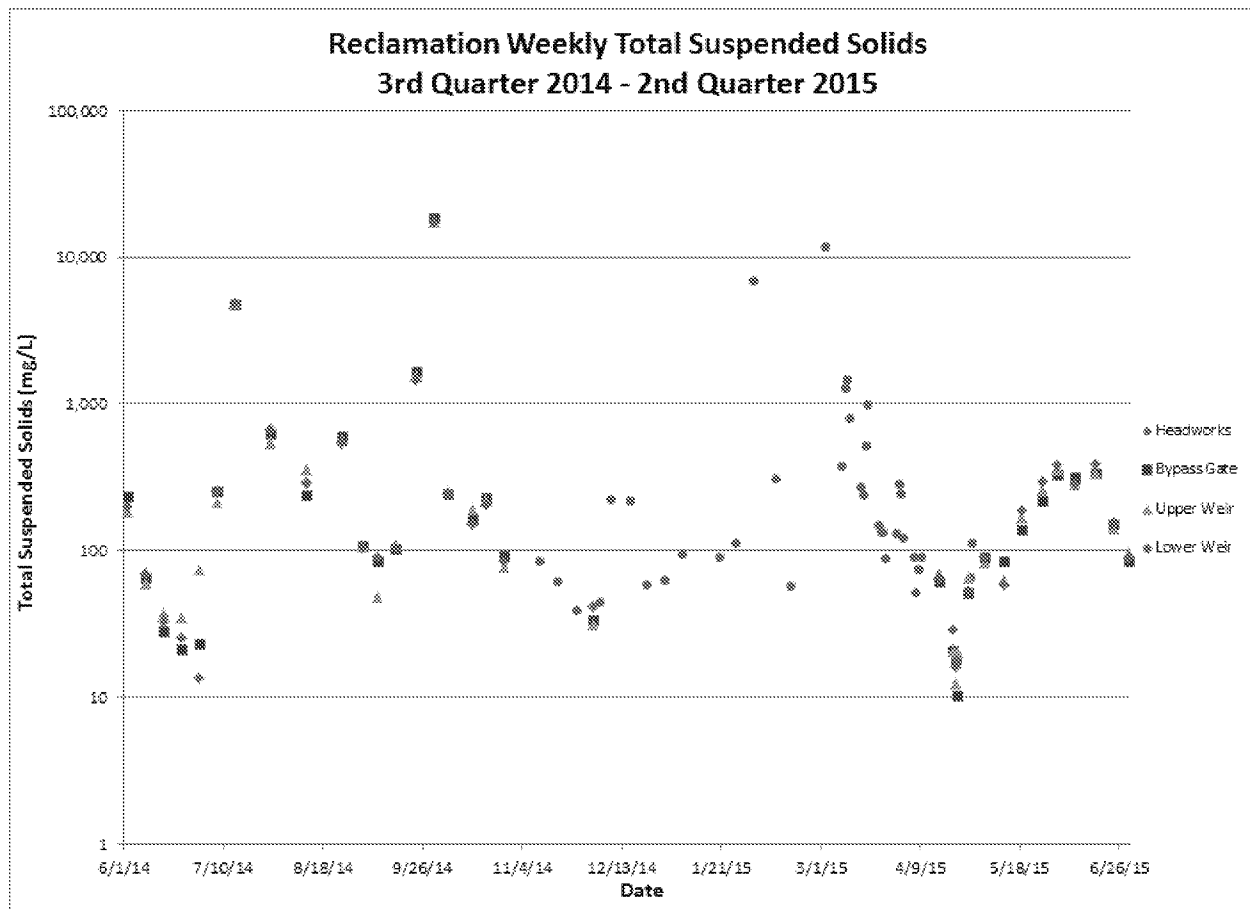


Figure 10. Reclamation Weekly Turbidity Data

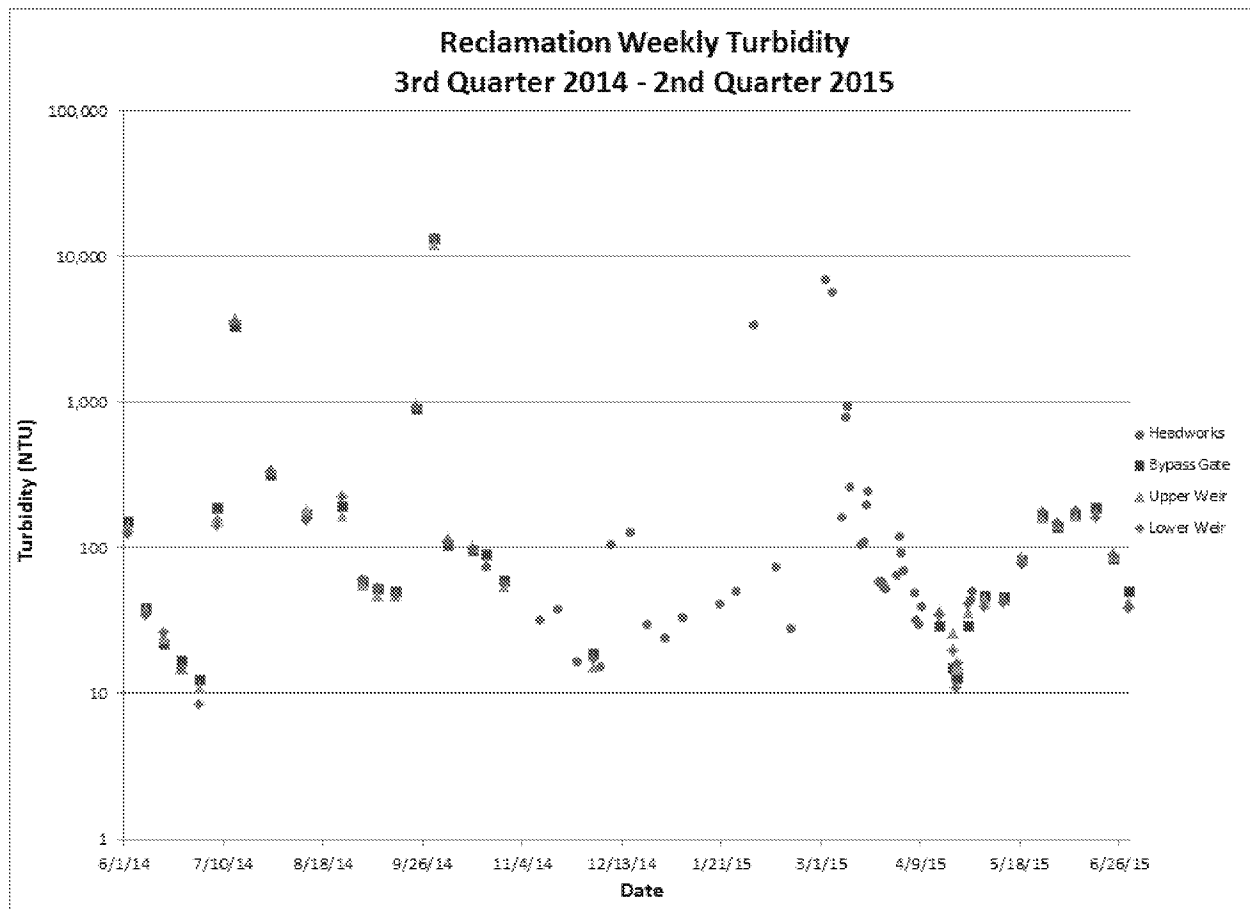


Figure 11. Reclamation Total and Dissolved Organic Carbon

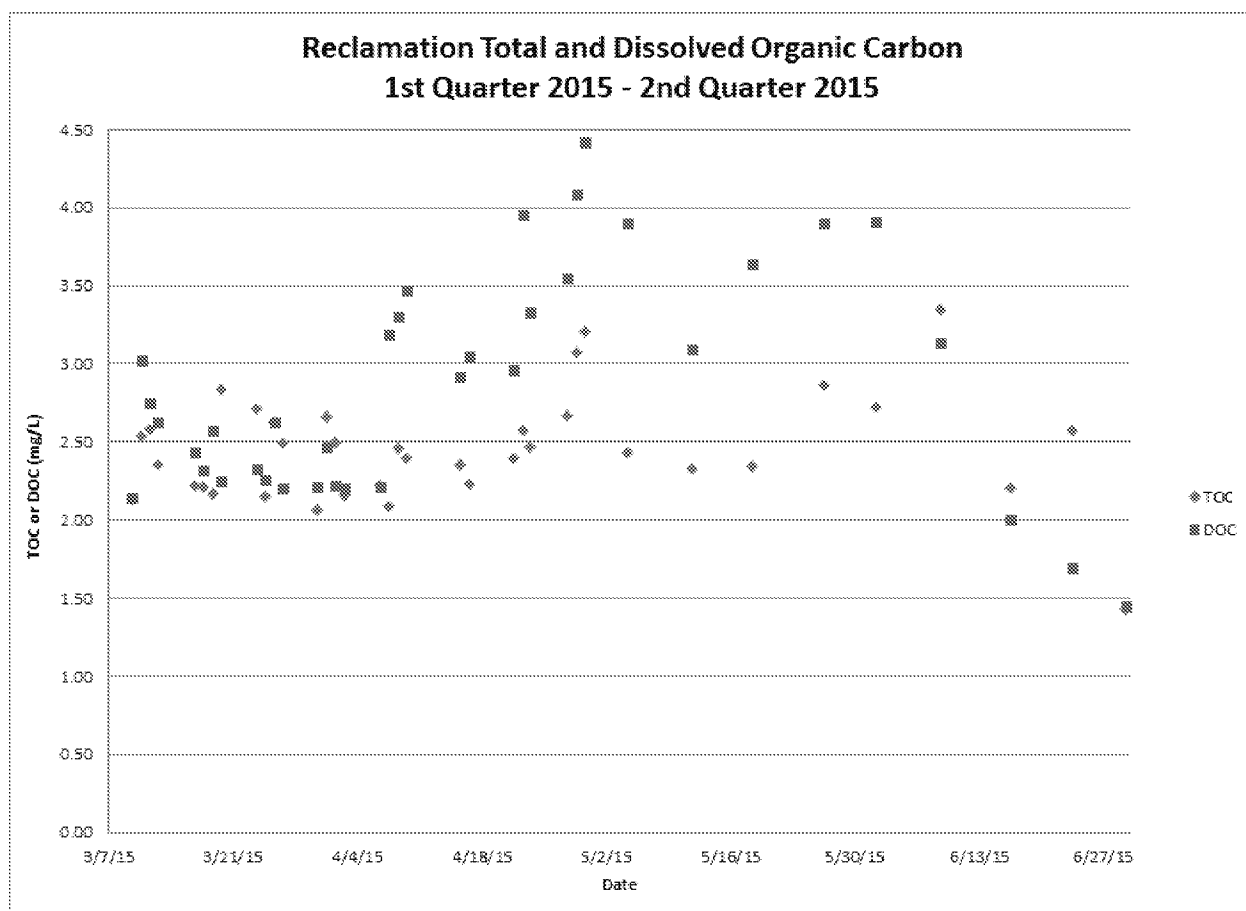
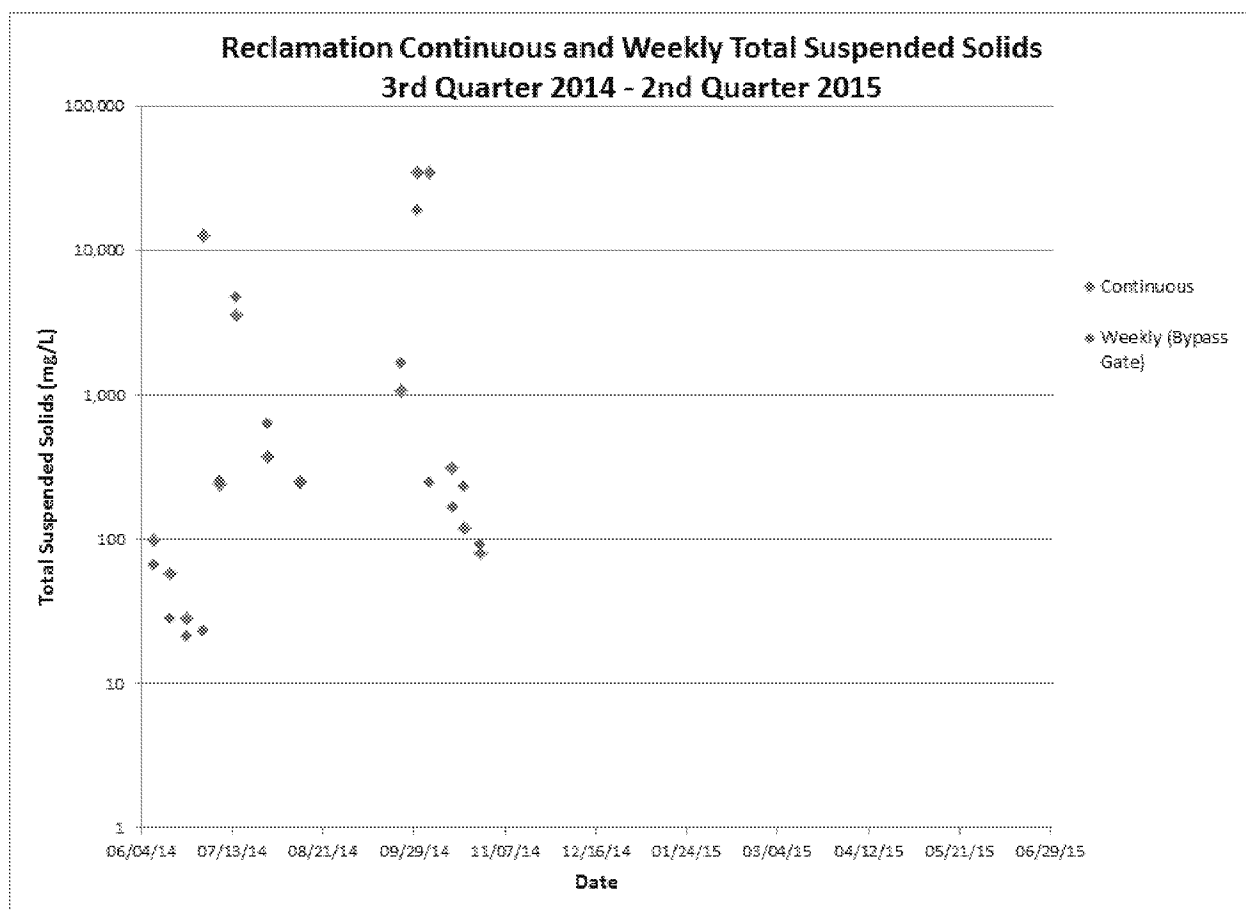
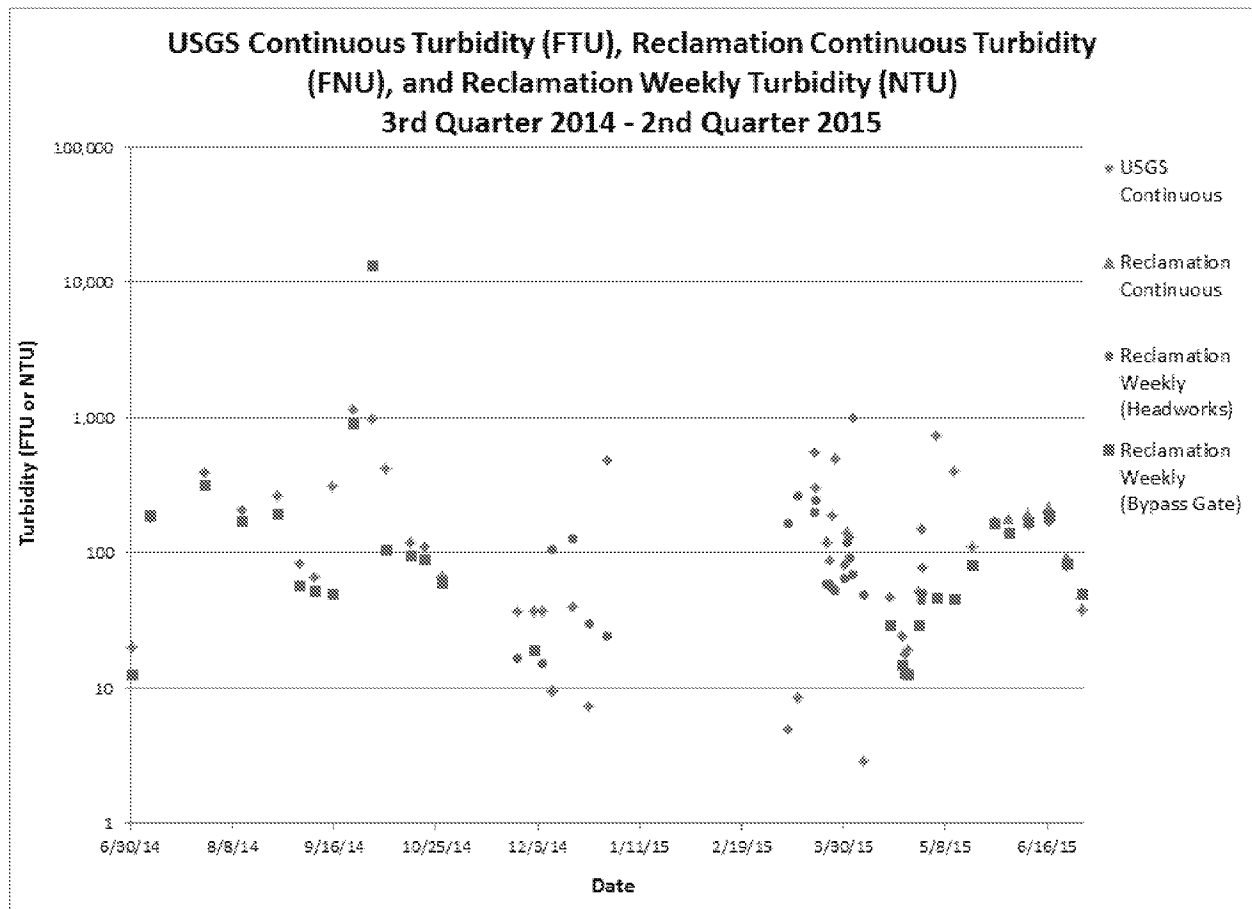


Figure 12. Comparison of Reclamation Continuous and Weekly TSS Data



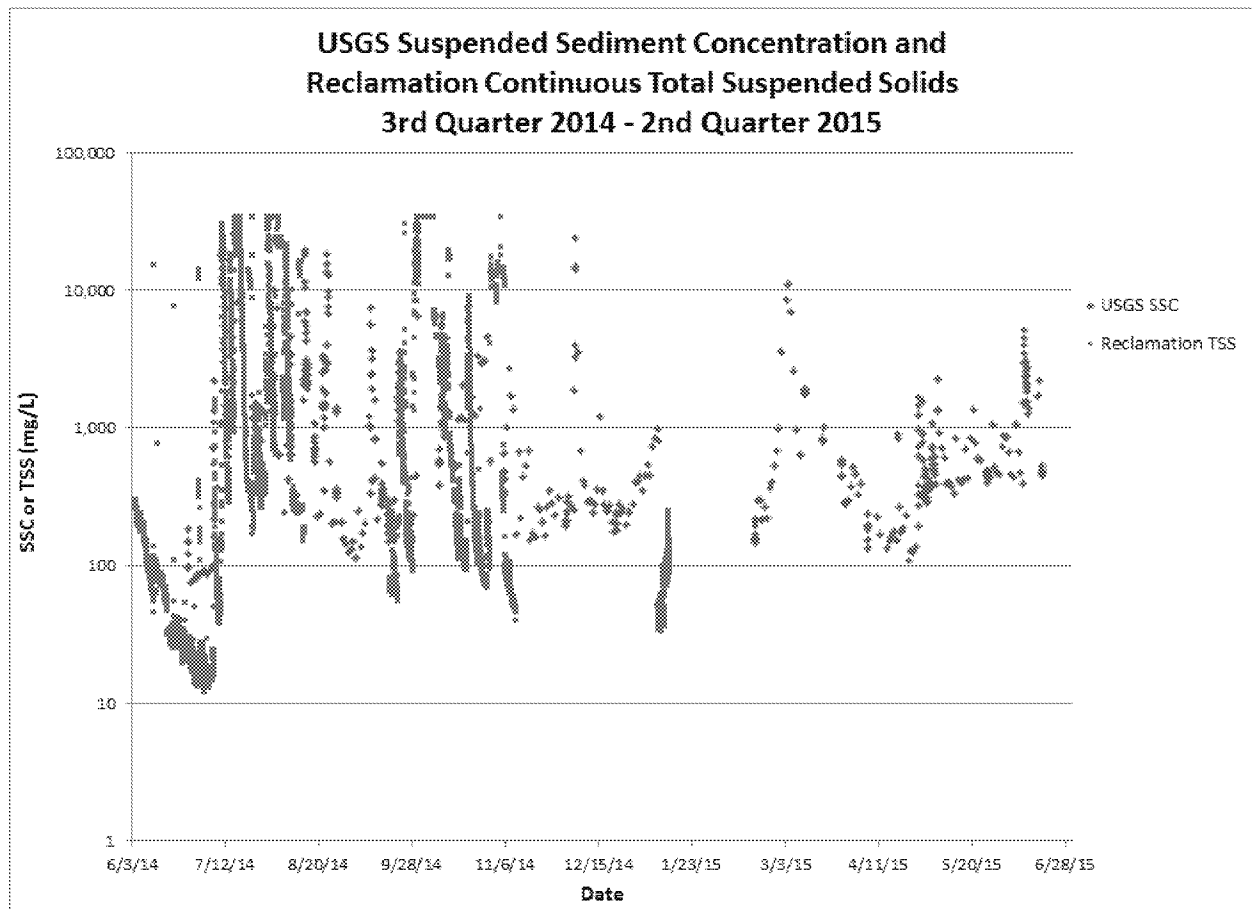
Note: Continuous instrument range is limited to $\leq 34,845$ mg/L. Continuous data collected from 11/10/14 to 1/8/15 differed significantly from lab results, was deemed erroneous, and was removed from the graph. No continuous Reclamation TSS data was collected after January 13, 2015 because power was not available at the site.

Figure 13. Comparison of USGS Continuous, Reclamation Continuous, and Reclamation Weekly Turbidity Data



Note: USGS turbidity data is provisional and subject to revision.

Figure 14. Comparison of USGS Suspended Sediment Concentration and Continuous Reclamation TSS Data



Note: Reclamation continuous instrument range is limited to $\leq 34,845$ mg/L. Reclamation continuous data collected from 11/10/14 to 1/8/15 differed significantly from lab results, was deemed erroneous, and was removed from the graph. No continuous Reclamation TSS data was collected after January 13, 2015 because power was not available at the site.

Figure 15. Comparison of USGS Turbidity and Continuous Reclamation Turbidity Data

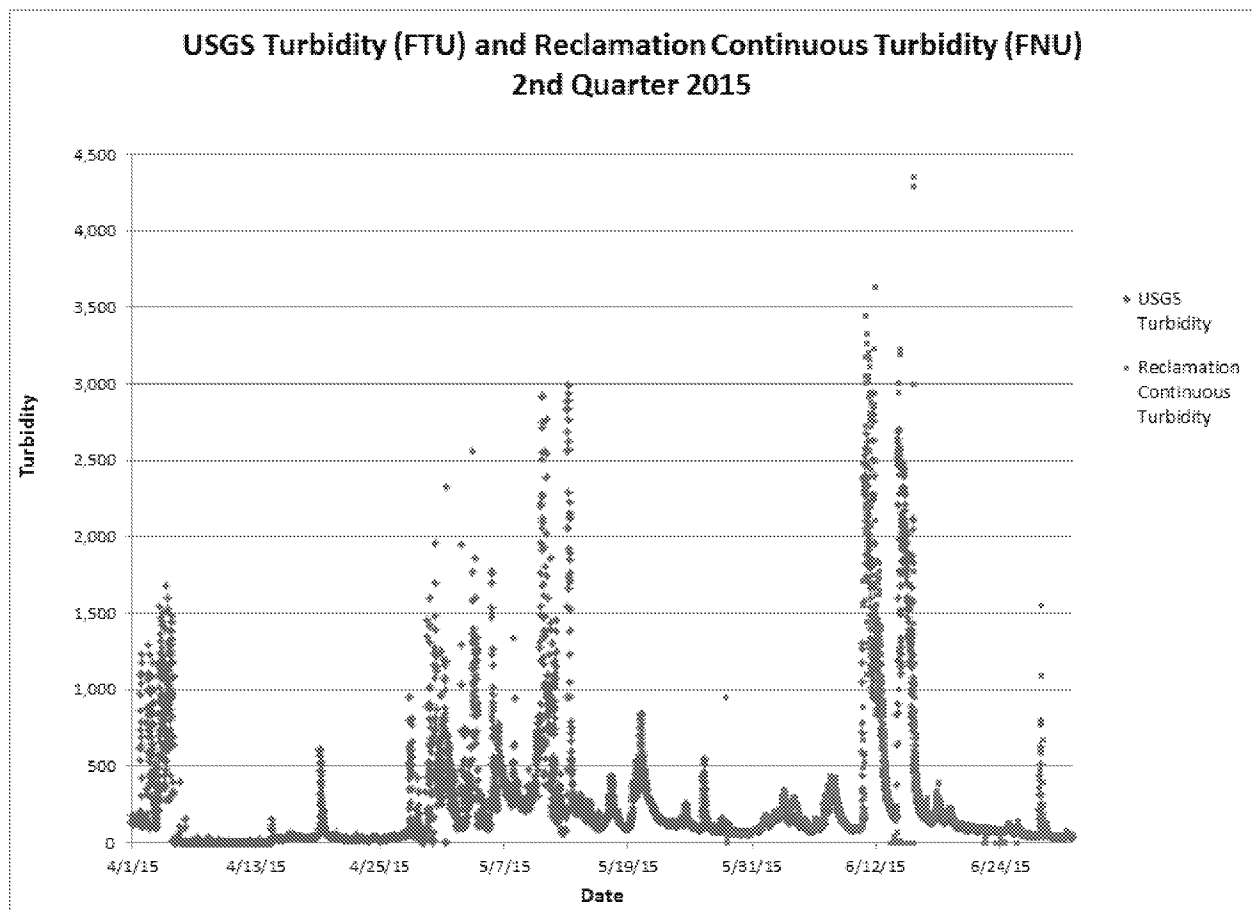
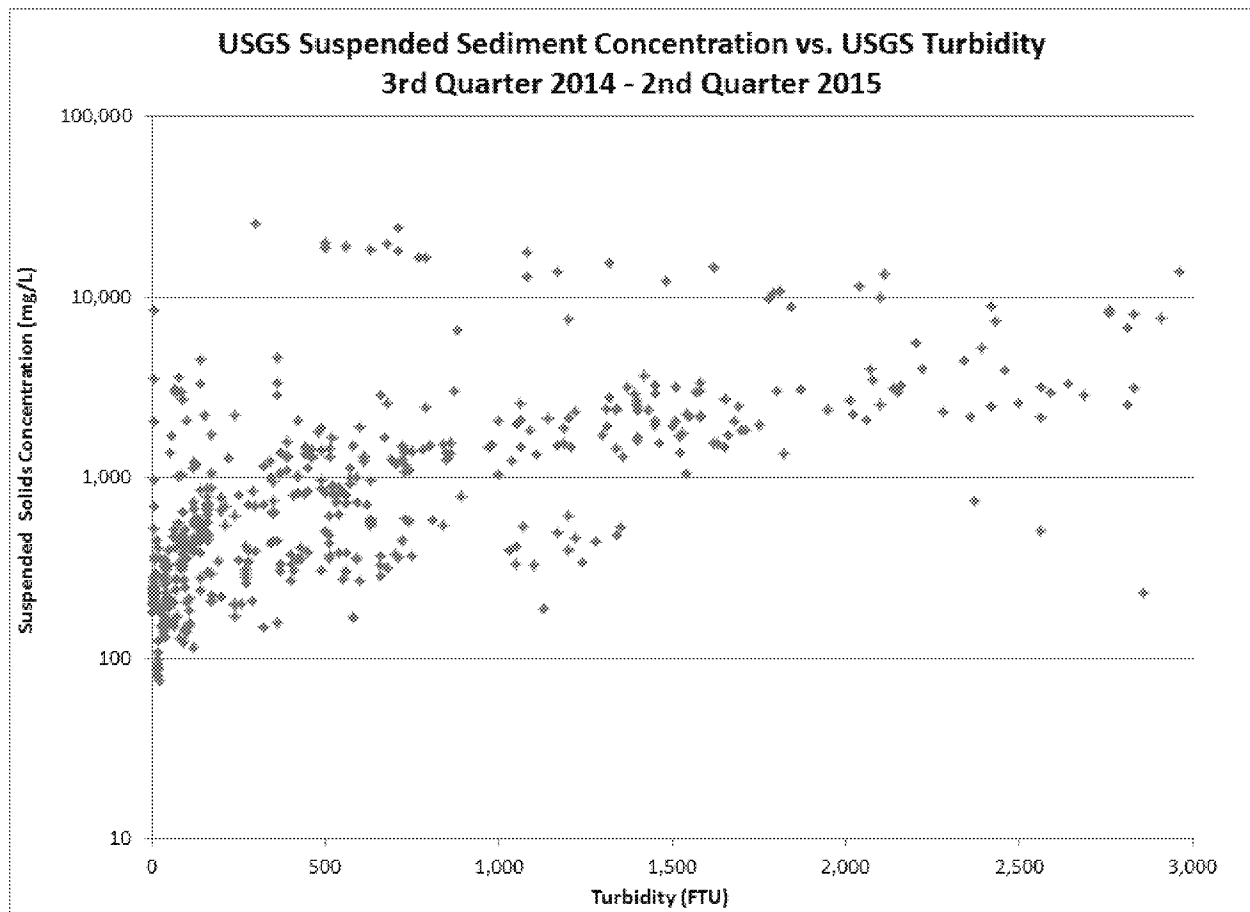


Figure 16. USGS Suspended Sediment Concentration vs. USGS Turbidity



Note: Although the USGS turbidity instrument range is limited to < 3000-FTU, no turbidity measurements in this data set reached this upper limit. USGS turbidity data is provisional and subject to revision.

Figure 17. Reclamation TSS Data vs. Reclamation Turbidity

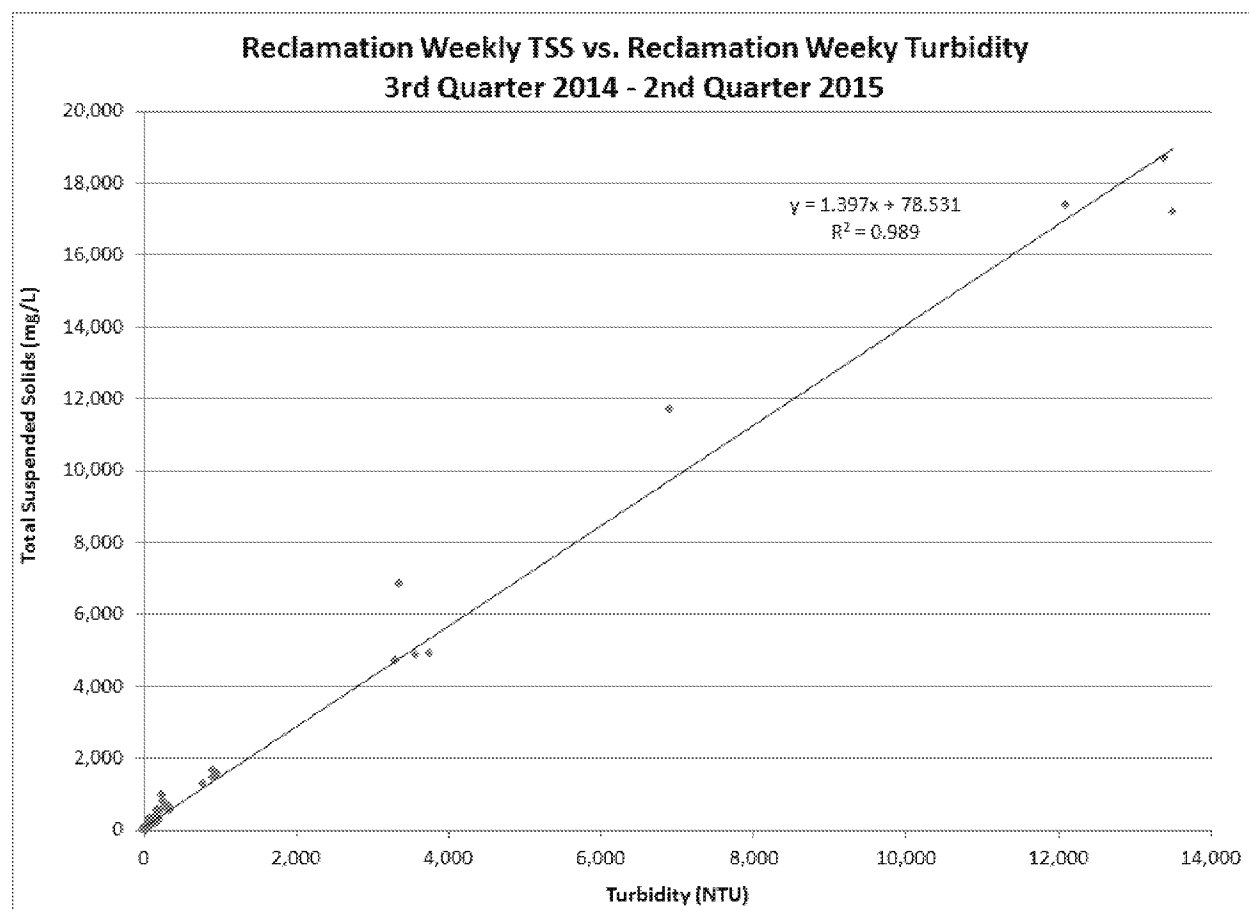


Figure 18. Reclamation TSS Data vs. Reclamation Turbidity <1,000 NTU

